GAS BUBBLE TRAUMA IN SNAKE AND COLUMBIA RIVER SALMON 9300802

SHORT DESCRIPTION:
Determine the relation between supersaturation levels, flow rates, fish movements, fish distribution, and GBT symptoms. Develop sample techniques, logistics, schedules, and collect preliminary data for use in design of future experiments to determine occurrence of symptoms among migrating smolts.

SPONSOR/CONTRACTOR: CRITFC
Columbia River Inter-Tribal Fish Commission
Dr. Tom Backman, SENIOR FISHERIES SCIENTIST
729 N.E. Oregon, Suite 200, Portland, OR 97232
503/731-1267 TWHB@AOL.COM

SUB-CONTRACTORS:
N/A

GOALS

GENERAL:
Adaptive management (research or M&E), Program coordination or planning

ANADROMOUS FISH:
Research, M&E

NPPC PROGRAM MEASURE:
5.6E.1

RELATION TO MEASURE:
This project is a multi year, multi-analytical project studying the relation between spill levels at mainstem federal projects, and the resulting total dissolved gas level, and its effects on the juvenile and adult salmon of the Columbia and Snake river systems.

BIOLOGICAL OPINION ID:
NMFS BO RPA Sec. 16 + waivers

TARGET STOCK	LIFE STAGE	MGMT CODE (see below)
Coho	Juvenile	S
Sockeye	Juvenile	L
Steelhead	Juvenile, ault	P
Chinook	Juvenile, adult	L

AFFECTED STOCK	BENEFIT OR DETRIMENT
Resident species	

BACKGROUND

Subbasin:
Lower and Mid-Columbia Mainstem and Snake River Mainstem

Hydro project mitigated:
Concerns all federally operated dams located within the Columbia and Snake river systems.

HISTORY:
N/A

BIOLOGICAL RESULTS ACHIEVED:
Juvenile results: In 1996 a total of 5,018 fish were examined for the prevalence of gas bubble trauma symptoms. Of the 5,018 fish

sampled, 4,904 were juvenile salmonids and 114 were a variety of resident species. In 1996, in-river symptom prevalence never exceeded 6.1% prevalence when sample size was greater than 43 individuals. This value was well below the 15% critical prevalence level set by the National Marine Fisheries Service. Fish exhibiting symptoms varied from rank 1 (the lowest severity level, <5% fin occlusion) to rank 3 (26% to 50% fin occlusion). The majority of symptomatic fish (85% or 17 of 20 smolts) were of a rank 1. No fish received a rank of 4, the most severe ranking (greater than 50% fin occlusion), during the course of the study. Of the smolts examined at the bypass, 3.3% had symptoms compared to 0.6% of in-river fish exhibiting symptoms on concurrent sampling dates. Results were based on cumulative numbers from 25 individuals comparisons. Of the 3,425 smolts collected in the river, 20 had symptoms. In comparison, of the 3,502 smolts collected at the bypass facilities on concurrent sampling dates, 114 had symptoms. A statistically significant difference existed between in-river and bypass sampled fish at three of the four dams sampled. Adult results: In 1996 adult salmonids were sampled at Bonneville Dam. It was found that of 2,026 adult salmonids sampled only 4 revealed symptoms.

PROJECT REPORTS AND PAPERS:

Two annual (1995 & 1996) technical reports have been submitted to BPA. Data summaries will continue to be provided to BPA, NMFS, and the Fish Passage Center. A final report will be published, and a paper will be published in a refereed journal.

ADAPTIVE MANAGEMENT IMPLICATIONS:

Data from the monitoring of levels of in-river gas bubble trauma in salmonids may be used in an adaptive management process. They are used in the present spill management decision making process. If further results of in-river studies differ from those of the smolt-monitoring program, the monitoring program may need to be adapted. Changes may be necessary in GBT reporting to correct for bias, and in-river sampling results may become part of the monitoring program. The results of this investigation may guide the development of future in-river monitoring activities.

PURPOSE AND METHODS

SPECIFIC MEASUREABLE OBJECTIVES:

Phase II. - Implement changes considered necessary from Phase I (1996) research. Phase II consists of three primary objectives: (1) Measure the frequency and severity of GBT symptoms in adult salmonids at Bonneville Dam, at available ceremonial and subsistence (C&S) fishing sites, and at the Three Mile Dam facility. (2) Measure the frequency and severity of GBT symptoms in in-river juvenile salmon. (3) Utilize a combination of hydroacoustic technology, water mass tracking, pit tag monitoring,and fish sampling in the McNary Dam reservoir and other suspected "hot spots" to initiate experimental study and further define the relation between gas supersaturation levels (and other physical factors), survival and the frequency and severity of GBT symptoms in in-river juvenile salmonids.

CRITICAL UNCERTAINTIES:

The transportation of juvenile fish could hamper our ability to collect sufficient sample sizes. Low spill levels, and therefore low TDGS levels, could limit our ability to sample smolts exposed to elevated gas levels. Weather and river conditions can also limit our ability our ability to conduct sampling. Lastly, because of the multi-analytical nature of this project, lack of funding to projects collaborating and correlating with this study could impede the overall progress of this research.

BIOLOGICAL NEED:

This is a mainstem, in-river project and our results are applicable to all up-river priority stocks. The results from experime nts in reservoirs will provide information to several user groups interested in gas abatement, water management, and smolt survival. The field experiments will be used to validate fishery agencies and tribal Smolt Monitoring Program's (SMP) results. Results will also be used to better interpret experiments conducted by other investigators in controlled laboratory environments. In addition, field investigations will provide researchers with in-river supersaturation and symptom conditions to direct future studies using controlled experiments to determine dose-response relations of fish. The results will aid in developing simulation models by providing quantitative parameter values for the factors measured and by generating empirical data to test new models. These data will provide managers with a better picture of the actual physiological and ecological conditions fish experience. Furthermore, if the findings indicate a monitoring program for symptoms in smolts in reservoirs is necessary, then results will provide a basis for managers to design such a program.

HYPOTHESIS TO BE TESTED:

Ho: There are no differences in prevalence and severity of gas bubble trauma symptoms between in-river and bypass sampled fish.

ALTERNATIVE APPROACHES:
N/A

JUSTIFICATION FOR PLANNING:
N/A

METHODS:
Objective A1: To measure the frequency and severity of symptoms in adult salmonids at Bonneville Dam, at ceremonial and subsistence platforms, and at the Three Mile Dam collection facility. Bonneville Dam (RM 146.1) was selected because it is the first dam adult fish encounter on their return migration and has levels of supersaturation typical for the Columbia River. This will be a continuation of the present adult monitoring program at Bonneville Dam. Sockeye (Oncorhynchus nerka), chinook salmon (O. tshawytscha), and steelhead (O. mykiss) will be trapped at existing fish traps and examined. Sampling at Bonneville Dam will be conducted three days per week, generally Monday, Wednesday, and Friday, for 6-8 hours per day between 13 May and 28 June, 1997. Sampling will be discontinued when spill does not occur. We expect to sample 3% to 6% of the adult salmonids passing Bonneville dam during the period in which monitoring is conducted. The gas bubble technical working group has indicated a need for additional adult sampling locations throughout the adult migration route. For 1997 we propose to conduct a feasibility study to determine if a significant number of adults can be examined during the tribal ceremonial and subsistence fishery, and at the adult collection facility at Three Mile Dam. A trained biologist will work with tribal fisherman to examine fresh caught adult salmon for GBT symptoms. Symptoms of GBD have been noted informally for the past two years (Brian Zimmer, personal communication) at Three Mile Dam. The existing fish examination program will be expanded to include observations of external signs of GBD. We propose to provide training, QA/QC review, and data management to insure timely and quality data from the Three Mile Dam facility. No specific schedule is provided because of uncertainties in return rates and locations. That will be determined during the adult migration season between April,1 1997 and the end of the 1997 spill season.

Examination procedures: Each fish will be placed in a sampling tank, anesthetized, and carefully examined for external symptoms by using a headband binocular magnifier. Held with two hands at the water s surface, the specimen can be easily rotated along the axis of its body, thus allowing the inspection of both sides of the body and mouth cavity. External signs of gas bubble trauma included in the examination will be the presence of distended eyes, vesicles in the mouth, on the operculum, and between fin rays . Particular attention will be paid to the head, the operculum plates, and the insertion point of each fin ray. After examination, fish will be allowed to recover in fresh water and released.

Objective J1: Continue experiments at selected sites to compare the symptoms of bypass and in-river examined fish.

We will use the purse seine and trawl net methods described below to collect samples above the boat restricted zone in the forebay of McNary Dam, the tailrace of Bonneville Dam, and the river reach between The Dalles Dam and John Day Dam. We will focus on McNary Dam because this dam had a higher or equal percentage of symptoms (13%) than other dams during the 1995 spill season (McCann 1995), it is the first dam on the Columbia River to sample both mid-Columbia and Snake river fish, and we found the site to be suitable for collecting and examining fish in 1996. Specific sampling times and locations depend upon river conditions, fish movement, and availability. The 1996 sampling program was initiated after the bulk of spring migrants and high levels of TDGS had passed. Therefore, we will attempt to obtain a substantial sample in the early spring (March or April). Hydroacoustic data and sampling confirmed that fish descend to deeper waters near dusk. Thus, the emphasis will be on day time sampling extending into the evening if fish numbers are low. When fish were present we found that a purse seine could obtain samples of 20 to 300 fish per set. When fish were deep or less abundant, trawls provided additional fish. Both methods described below may be modified to improve sampling efficiency.

Purse seine collection method: A purse seine, approximately 130 m in length and five-m in depth with a 2.5 cm stretch mesh, will be deployed off the deck of a 24-ft boat with the assistance of another 18-ft boat. When fishing the net, the boats will run up-river parallel to one another with the purse seine stretched between them. Boat speed will be adjusted to maintain the net vertically in the water column. After fishing between two and 10 min, the purse seine will be retrieved by the 24-foot boat. The seine will then be pursed with the aid of a capstan hydraulic system. The portion of the net containing the trapped fish will be allowed to stay in the river while the fish are retrieved with a sanctuary dip net and placed in a 50-gallon live box filled with circulating river water. Captured fish will then be transferred to the mobile fish lab. The time the net was set, the time the net

was pulled, location (river mile and G.P.S.), and depth will be recorded for each set.

Trawl net method: A rectangular 8 m by 4 m trawl with 2.5 cm stretch mesh will be pulled with a 24-ft boat. This trawl will be utilized to collect fish from various depths, from the surface to depths of up to 50 ft. We will, however, focus primarily on sampling within the top portion of the water column (top 2 m). We have modified the opening and closing trawl, developed by Enzenhofer and Hume (1989). The advantage over conventional nets is the ability to lower the trawl to specific depths and to retrieve the trawl with the mouth closed. This will ensure that the fish collected are from a selected depth and not from shallower depths during deployment. Time and depth of the trawl net will be recorded with a Mk5 time-depth recorder. The trawl's cod-end is fitted with a sanctuary trap constructed from a 50-gal plastic container. This configuration will allow the sanctuary container to hold fish in water as it is brought aboard. The fish will then be transferred with a sanctuary dip net to a live box with circulating river water and brought to the examination station. The trawl was able to sample at selected depths during the 1996 season, but this method of entrapment was found to cause excessive stress and harm to the smolts. Continued use of this method will therefore depend upon the ability to improve the trawl and minimize stress to the smolts.

Examination procedures: Once collected, fish will be transferred from the boat to a mobile examination station in 45 plastic buckets. Approximately 5-10 fish will then be transferred to a 8 plastic bucket containing a buffered MS-222 solution (approximately 30 ppm) and held until they can be examined by trained personnel. During the examination, the fish will be held in a tray containing water. Fish will always be held in water and will be quickly transferred between buckets of water in soft nets. Smolts will be passed by a Passive Integrated Transponder (PIT) tag detector prior to examination.

Examination procedures will continue to follow the protocol of the Smolt Monitoring Project. Fish will be examined using a variable magnification (6X to 40X) dissecting microscope. The body, unpaired fins, eyes, opercula, and lateral line on the left side of the fish will be examined for symptoms. Additional data including species, fork length, origin (hatchery, wild, or unknown), the presence of disease or injury, and degree of descaling will also be recorded for each fish. The examination time will be less than 1 minute per fish. After the examination, the fish will be placed into plastic buckets containing fresh river water and allowed to recover from the anesthetic. Once normal swimming behavior is observed, the fish will be released into the river.
Statistical Procedure: Sample size required to compare symptoms: The sample size required to determine if a significant difference could accurately be detected between bypass examined fish and in-river examined fish was determined using a computer program called Design-Power (Barvy, Scientific Software, Inc., 1987). The Design-Power program that related to our sample size simulations is based on power and sample size equations from Cohen (1977), and Snedecor and Cochran (1967). In-river capture of 200 fish would allow us to detect a 5% difference, at power of 0.90, in symptoms between in-river and bypass samples. Further increasing sample size to over 200 individuals does little to increase the power of comparison due to the exponential relation of sample size and power. Detecting a 5% difference in symptom prevalence is a stringent enough standard to draw scientifically sound inferences. Our simulations, based on sample size and power criteria, are designed to help us assess in-river sampling effort and determine what catch numbers will result in accurate symptom comparisons.

Statistical tests between in-river and bypass samples: Statistical comparisons (testing the H :) between in-river and bypass sampled smolts will be performed with the aid of the log-likelihood ratio test, which utilizes the G-statistic. The G-test is recommended to avoid the increased likelihood of a type I error (rejection of a null hypothesis when it is really a true statement), resulting from low expected frequencies (Zar, 1984). Furthermore, the 2 x 2 G-test is regarded as the best method for independent testing of proportions or percentages (Sokal and Rohlf 1981). Heterogeneity G-tests or interaction tests will also be performed to examine the over-all relationship between symptom prevalence and sampling site. The heterogeneity G-test provides cumulative information on sets or replicas of similar data (Sokal and Rohlf 1981). An interaction analysis, therefore, will allow us to draw statistical inferences about differences, or the lack of, between in-river and bypass smolts for an entire river reach or sample location.

Task J.2: Further improve the operation of depth selective trawl net and design changes to reduce harm to sampled fish. Conduct near surface and near shore hydroacoustic developmental studies(BRD) and continue to develop and deploy nets and trawls to sample fish as needed.

The approach for this study will be to sample transects using the hydroacoustic survey system developed by BRD. This system can be used to determine fish distribution, sampling locations(via a G.P.S. device), and water velocities in the study area with the use of an acoustic doppler current profile. Additional measurements will include supersaturation levels, temperature, and turbidity. The transects used in prior investigations have been parallel to each other and perpendicular to the shoreline, but the

orientation may be changed depending on hydroacoustic transducer deployment constraints. Simulation studies indicate that stratified parallel transects are more efficient at low sampling intensities than alternative transect designs (Kimura and Lembeg 1981). In-river sampling operations, as described under task J1.1, will be conducted concurrently with the hydroacoustic surveys.

PLANNED ACTIVITIES

SCHEDULE:

Implementation Phase **Start** 1/98 **End** 12/01 **Subcontractor** N

Task Phase III. Spring-Summer 1998 - Continue and modify multi-analytical study from information gathered from 1997 research. Changes may include modifications to associated research projects, modifications of sampling sites, modifications of sampling procedures, and additional statistical analysis.

PROJECT COMPLETION DATE:

2001

CONSTRAINTS OR FACTORS THAT MAY CAUSE SCHEDULE OR BUDGET CHANGES:

Further ESA listing of species could influence sampling efforts and schedules. On a smaller scale, unpredictable weather or river conditions during the field season could affect our sampling schedule.

OUTCOMES, MONITORING AND EVALUATION

SUMMARY OF EXPECTED OUTCOMES

Expected performance of target population or quality change in land area affected:

Research is designed primarily to test critical uncertainty in the monitoring program. Recommendations, based on research results, are therefore pending.

Present utilization and convservation potential of target population or area:

Salmon are used extensively for both commercial, tribal ceremonial and subsistence, and recreational fishing.

Assumed historic status of utilization and conservation potential:

Commercial, ceremonial and subsistence, and recreational fishing.

Long term expected utilization and conservation potential for target population or habitat:

To be able to assess the degree that salmon are affected by elevated total dissolved gas levels. And to further define the relation among supersaturation, juvenile salmonid distributions, and the prevalence of symptoms.

Contribution toward long-term goal:

The results from experiments in reservoirs will provide information to several user groups interested in gas abatement, water management, and smolt survival. The field experiments will be used to validate the fishery agency and tribal Smolt Monitoring Program's (SMP) results and to interpret results from experiments conducted by other investigators in controlled laboratory environments. In addition, field investigations will provide researchers with in-river supersaturation and symptom conditions to direct future study using controlled experiments to determine dose-response relations of fish. The results will aid in developing simulation models by providing quantitative parameter values for the factors measured and by generating empirical data to test new models. These data will provide managers with a better picture of actual physiological and ecological conditions fish experience. Furthermore, if the findings indicate a monitoring program for symptoms in smolts in reservoirs is necessary, then results will provide a basis for managers to design such a program.

Indirect biological or environmental changes:

Further understanding of the relation between supersaturation, juvenile salmonid distributions, and the prevalence of symptoms, c

ould help hydro operators, fishery managers, and researchers make management decisions concerning spill, flow, temperature, and dam and bypass engineering.

Physical products:
N/A

Environmental attributes affected by the project:
Spill is the primary attribute likely to be affected by the outcome of this research. Secondary environmental attributes affected by the project include variables such as flow and temperature.

Changes assumed or expected for affected environmental attributes:
Increased or decreased spill, dependant on outcome of research.

Measure of attribute changes:
N/A

Assessment of effects on project outcomes of critical uncertainty:
The critical uncertainties associated with this project relate primarily to our ability to gather significant in-river samples to compare with bypass collected samples. Therefore, the assessment of project outcomes of critical uncertainties will most likely be assessed through the statistical validity of our samples.

Information products:
The project is a monitoring project to evaluate how well GBT symptom data collected at smolt bypass facilities represents actual in-river symptoms. The field experiments will also be used to interpret results from experiments conducted by other investigators in controlled laboratory experiments. Several user groups interested in gas abatement, water management, and smolt survival could use this data for decision analysis.

Coordination outcomes:
This project will coordinate with a variety of organizations. We will work with BRD and their hydroacoustic study, USACOE's and their gas measurement program, the NMFS 1997 pit tagging program, and the FPC for coordination of sampling location and dates.

MONITORING APPROACH
The results from experiments in reservoirs will provide information to several user groups interested in gas abatement, water management, and smolt survival. The field experiments will be used to validate the fishery agency and tribal Smolt Monitoring Program's (SMP) results and to interpret results from experiments conducted by other investigators in controlled laboratory environments. In addition, field investigations will provide researchers with in-river supersaturation and symptom conditions to direct future study using controlled experiments to determine dose-response relations of fish. The results will aid in developing simulation models by providing quantitative parameter values for the factors measured and by generating empirical data to test new models. These data will provide managers with a better picture of actual physiological and ecological conditions fish experience. Furthermore, if the findings indicate a monitoring program for symptoms in smolts in reservoirs is necessary, then results will provide a basis for managers to design such a program.

Provisions to monitor population status or habitat quality:
Both adult and juvenile salmon population and outmigration numbers are closely monitored at a variety of dams on the Columbia and Snake rivers by the Fish Passage Center.

Data analysis and evaluation:
An adaptive management approach will be used to analyze data.

Information feed back to management decisions:

If the findings indicate a monitoring program for symptoms in smolts in reservoirs is necessary, then results will provide a basis for managers to design such a program.

Critical uncertainties affecting project's outcomes:
Funding of this project, as well as related projects, prior to the onset of the field season would allow for sampling in the early spring when fish are relatively abundant and TDGS levels are high. Sampling in locations more likely to offer consistent, workable river and weather conditions would increase sampling efficiency and effort. On a broader scale, a major uncertainty not covered by this project is the extent of smolt mortality from GBT, we therefore cannot quantify the relation between GBT and mortality.

EVALUATION
Review of projects results (i.e. annual report) should provide suitable information needed to assess the projects overall performance. Achievement of project goals, as stated in the statement of work, will also indicate projects success.

Incorporating new information regarding uncertainties:
An open forum between related projects and agencies had been developed. If new developments arise concerning uncertainties all intereseted parties will discuss the options available.

Increasing public awareness of F&W activities:
Our project is a highly visible in-river project. Personnel are always open to field questions from the general public regarding the project.

RELATIONSHIPS

RELATED BPA PROJECT	RELATIONSHIP
USACOE performs gas monitoring at dams.	WILL ALLOW FOR CONSISTENT MONITORING OF GAS LEVELS. CAN DRAW INFERENCES TO THE LEVEL OF TDGS SAMPLED FISH HAVE BEEN EXPOSED TO.
The FPC performs smolt monitoring at bypass facilities	THIS STUDY WILL ALLOW FOR A COMPARISON BETWEEN IN-RIVER SAMPLED FISH AND BYPASS SAMPLED FISH

RELATED NON-BPA PROJECT	RELATIONSHIP
	The BRD performs hydroacoustic work. THIS STUDY WILL COORDINATE WITH THE IN-RIVER GBT SAMPLING STUDY BY AIDING IN IDENTIFYING THE DEPTH DISTRIBUTION AND FISH DENSITIES OF JUVENILE SALMONIDS.

OPPORTUNITIES FOR COOPERATION:
Close coordination between the USACE, BRD, NMFS, the Fish Passage Center, and CRITFC will be important in achieving this project's objectives. The USACE has primary responsibility for the enumeration of gas plumes in the study areas. Dennis W. Rondorf (BRD) will have primary responsibility for collecting and analyzing hydroacoustic data and TDGS levels. Alec G. Maule (BRD) will have primary responsibility for Gas Bubble Trauma symptom protocols and quality assurance. FPC will monitor GBT symptoms within the bypass system. Tom W.H. Backman (CRITFC) will have responsibility for coordinating activities of the adult and in-river juvenile sampling. Coordination of funding by USACE and BPA will be required. The funding for the BRD involvement (hydroacoustic, training and quality assurance under tasks J1.2, J2.1.1, J2.1.2, J2.1.3 and J2.2) has been requested of the USACE.

COSTS AND FTE

1997 Planned: $675,000

FUTURE FUNDING NEEDS:

FY	$ NEED	% PLAN	% IMPLEMENT	% O AND M
1998	$900,000	25%	75%	
1999	$900,000		100%	

PAST OBLIGATIONS (incl. 1997 if done):

FY	OBLIGATED
1995	$153,378
1996	$505,794
TOTAL:	$659,172

Note: Data are past obligations, or amounts committed by year, not amounts billed. Does not include data for related projects.

OTHER NON-FINANCIAL SUPPORTERS:
The Fish Passage Center The Biological Resources Division The National Marine Fisheries Service

LONGER TERM COSTS: N/A

1997 OVERHEAD PERCENT: 44%

HOW DOES PERCENTAGE APPLY TO DIRECT COSTS:
[Overhead % not provided so BPA appended older data.] Portion of direct cost

CONTRACTOR FTE: 15

SUBCONTRACTOR FTE: N/A